Spatial Planning and Decision Support System for Urban Metropolitan Planning and Monitoring: A Case of Klang Valley, Malaysia

Ahris Yaakup
Ahmad Nazri Muhammad Ludin
Siti Zalina Abu Bakar
Susilawati Sulaiman
Department of Urban and Regional Planning
Faculty of Built Environment
Universiti Teknologi Malaysia
81310 Skudai, Johor, Malaysia.
Email: b-haris@utm.my / ugisp_bip@yahoo.com

Ramli Zulkifli
Lily Hammadah Ramle
Ministry of Federal Territories
Aras 1-4, Blok 2, Menara PjH,
Presint 2, 62100 Putrajaya, Malaysia
Email: lily@kwp.gov.my

Abstract

Planning methodology has changed over the years following the shift of emphasis from producing plan, which described a state of affairs expected of some future date, to one acknowledging the continuous and cyclical nature of planning. This necessitates planning be based on the identification of needs and goals, the formulation and evaluation of alternative courses of action and monitoring of adopted programmes. It can be traced that the development of planning support system run parallel from the 'database' to 'information' approach, starting from a focus on applied science in the 1960s through a profound consideration on the political process in the 1970s and to an emphasis on communication in the 1980s. The dynamic nature of planning and monitoring of development in Klang Valley, the fastest growing region in Peninsular Malaysia, apparently requires a 'tool' for continuous evaluation and analysis of current environment as well as the capacity for future development. Apart from managing the comprehensive GIS database, evaluation becomes an essential step in the planning process especially in selecting the appropriate development scenario alternative to be implemented. As such, the concept of Integrated Land use Assessment (ILA) was introduced through the "Application of GIS for Klang Valley Region" (AGISwlk) project. The ILA model developed is implemented through incorporation with the use of What-if Planning Support System, a scenario-based, policy-oriented planning support system. A user interface is also developed to ease the access and preparation of data from the AGISwlk database to run the ILA model and generate alternative scenarios. The introduction of ILA as an integrated land use planning approach that applies the GIS analysis capabilities while supported by the use of planning support system (*What if?*) is seen as a good alternative for achieving better and more rational decisions. The methodology was developed and organized based on the GIS spatial analysis process and planning support system framework as well as the identification of policy and strategy to be used as guideline and direction of study in achieving the desired output. The developed model is expected to dynamically support the preparation of the Klang Valley Regional Master Plan.

Key words: Planning, GIS, Development Plan, Planning Support Systems

INTRODUCTION

The current method of urban and regional planning adopted a continuous, cyclical system approach based on the identification of needs and goals, the formulation and evaluation of alternative courses of actions and monitoring adopted programmes. The task typically involves the identification of emerging land use patterns which are normally linked with other planning statistics such as population, employment and housing before the full significance of land use changes are apparent. This task is made difficult in many parts of the world where rapid urbanisation is presently taking place.

With the continued development of Information and Communication Technology (ICT), there is a major opportunity for the authorities to use it to manage the allocation of scarce resources in a rapidly changing environment. The quality of urban planning and management can be upgraded when available and valid data are handled in an advanced manner with the aid of computers. The adoption of innovative technology can support planning and decision-making by offering relatively quick response on analytical questions and monitoring issues. Some of the important functions include the ability to retrieve information rapidly and efficiently, to model different scenarios and to evaluate alternative solutions generated by various modeling procedures.

INFORMATION SYSTEM AND SPATIAL PLANNING

In an era of increasing urban and regional problems, the planning authority must increase their effectiveness by developing innovative ideas in carrying out their functions. The urban system can no longer be treated in terms of simple land use and traffic concepts. The planner's conception of the urban system must extend to include a host of social, political and economic variables. The mixture of problems which must all be resolved together, creates a situation in which many alternative must be tried, combined, improved and tested by analysis, by experiment, and by public discussion.

The Role Of SPDSS in Urban Planning and Monitoring

Planning methodology has changed over the years following the shift of emphasis from producing plan, which described a state of affairs expected of some future date, to one acknowledging the continuous and cyclical nature of planning. This necessitates planning be based on the identification of needs and goals, the formulation and evaluation of alternative courses of action and monitoring of adopted programmes. It can be traced that the development of planning support system run parallel from the 'database' to 'information' approach, starting from a focus on applied science in the 1960s through a profound consideration on the political process in the 1970s and to an emphasis on communication in the 1980s (Brail & Klosterman, 2001). The evolution of sciences and technology has effected the change of planning decision method. Planning support system (PSS) and decision support system (DSS) is one of tools for achieving planning quality in optimum development.

The recent widespread introduction of Geoinfomation Technology (GIT) provides an exciting potential for geographic information to be used more systematically and by greater diversity of discipline than ever before. The evolution of computer and information over the last few decades provides significant impact on the planning profession. Among the technological advancements, after microcomputer per se, GIS is perhaps the one that has been most attractive to planners. With its powerful capacity for spatial data management, spatial analysis and visualization, GIS provides planners with new tools to implement their work more efficiently. As spatial representation is critical to environmental problem solving, geospatial data and technologies apparently enable more effective and efficient operations, improved communications, and, ultimately, better decision-making. The capabilities of geospatial data and technologies also help empower citizens with vital information about their communities and deepen the capacity of citizens to make informed, collaborative decisions affecting their quality of life. While geospatial information are being used daily by almost every agency of the federal government and agencies of local governments, regional governments, and public authorities, much concern is given to effective methods of creating, obtaining and distributing information (Yaakup *et al.*, 2005a).

Development Planning System in Malaysia

Development planning requires an effective planning approach to achieve the desired goals and objectives, evaluate alternative as well as control development programmes that are in line with the current and future prospects. GIS technology has long been applied in planning activities which essentially include plans formulation as well as development control (Johar *et al.*, 2003).

In Malaysia, the recent amendment to the Town and Country Planning Act, 1976 (Act 172) in year 2001 requires the formulation of plans at various spatial and administrative levels to ensure effective planning. The various plans include:

- The National Physical Plan (RFN), which outlines the strategic policies for the purpose of determining the general direction and trend of the nation's physical development.
- The Regional Plan, which establishes policies to guide and coordinate development of a region especially in the provision of infrastructure and facilities within the region.
- The State Structure Plan (RSN), which sets out the policies and proposals for the development and use of the land in a state.
- The District Local Plan (RTD), which translates the state policies at local level.

The Manual published by the Federal Town and Country Planning Department for preparing the various levels of plan has provided that all plans use GIS technology in plan formulation. The different spatial level and form of plans requires different support in term of information system (Johar *et al.*, 2003). Various skills are also required for preparing development plans using GIS. They include the ability to build up and manage the database which should incorporate socio-economic attributes of the local population. Managing services at local level would also call for contiguity and proximity analysis. Cartographic skills are of importance if plans are to be exhibited.

In planning analyses, information is derived from printed map, field survey, aerial photographs and satellite images. GIS systems enable data from wide variety of sources to be integrated together in a common scheme of geographical referencing, thus providing up-to-date information (Grimshaw, 1988; Coulson and Bromley, 1990). A GIS is able to support all the stages of spatial data processing including manual or semi-automated digitizing, checking and editing of digitized data, edge-matching of digital map files and output of information to a graphics devise or hard copy plotter.

FACILITATING KLANG VALLEY URBAN METROPILITAN PLANNING AND MONITORING WITH SPDSS

Klang Valley Region has of late shown all the evidences of going through the metropolisation process (Yaakup *et al.*, 2004). The region is experiencing the highest rate of urban growth in the country. Faced with rapid growth, there is constant pressure on most urban areas in Klang Valley region to improve services while reducing costs, and to be more efficient and effective in its daily operations and management activities. The issues accompanying metropolisation process have long been of prime concern. It is aware that the process which indeed brings numerous benefits to the quality of urban life and environment, would also project negative effects in various aspects including economy, ecology and sociology. Rapid development and expansion of city limits have either directly or indirectly affected environmental quality, causing increase in temperature, geohazard occurrences as well as pollution from noise, air and water. Other problems include uncontrolled urban sprawl, congestion and increasing cost of service to cater for new infrastructure apart from the awaiting challenges such as socioeconomic disparities between regions, urban poverty and increase risk of social exclusion (Yaakup *et al.*, 2005b).

Apparently, the challenge of metropolitan solutions to urban change involve among others, the requirement for institutional frameworks which can manage the impacts ("externalities") accompanying the emergence of new patterns of interaction involved in the process of change, both through anticipating them and building them into policies, regulations, plans, and investment projects and also in mitigating their negative impacts (Cohen, 1999). As such, metropolitan frameworks need to be viewed in terms of a set of longer term of criteria for urban management.

Planning Applications for Development Monitoring and Assessment - The AGISwlk Project

In response to the current need for application of information technology for development planning and monitoring purpose, the Federal Territories Development and Klang Valley Planning Division (BKWPPLK) as the coordinator in the planning and development of Klang Valley had initiated the development of a comprehensive database and GIS-based planning applications under the project named “Application of Geographical Information System for Klang Valley Region (AGISwlk)” in 1995. AGISwlk had been designed and developed regionally to support ten main application modules namely built up area, green and recreational area, traffic and urban transportation, squatter and low cost housing, environment, utilities and community services, industrial and commercial development, population and socio-economic, geohazard and tourism. In order to support these application modules, ten elements of data have been prepared including base map, administrative boundary, physical characteristics, land development, population and socio-economic, environmental quality, traffic and urban transportation, green and recreational areas, public facilities and utilities (Yaakup *et al.*, 1999). It was to be used as a planning support tool for coordinating and monitoring the development of the region. Various analyses were carried out under each module through adoption of the spatial modelling techniques using various GIS spatial analysis functions.

The project had since been undergoing intensive enhancement in its database structure, data quantity and quality, analysis approach and techniques as well as system customisation and integration. The AGISwlk Web Application for Klang Valley was initiated as an extension to the prior developed database and application modules of AGISwlk. The web-based GIS applications developed adopted the three-tier client/server architecture comprising three main parts namely Clients, Middleware/Application Server and Data Storage (Yaakup *et al.*, 2001). Two application modules were developed to serve two different target groups base on the requirement and role of each one. The first module, which is the Public Interactive Maps Application aimed at providing information on Klang Valley apart from inviting public participation from the general public. The second module also known as the Stakeholder Application was designed for the purpose of data sharing and collaborative planning between government agencies and planning authorities involved directly in the planning and management process (Yaakup *et al.*, 2005a).

This project is considered successful and has significantly contributes to the understanding of the development characteristic of the Klang Valley region and thus helps in planning, coordinating and monitoring development programmes of the area through utilising every potential of the system mainly as a decision support tool. To certain extent, AGISwlk is seen able to help improve the decision-making process pertaining to the planning and monitoring of the region.

However, GIS alone cannot serve all the needs of planning because the current generation of “general purpose” systems cannot easily accommodate the particular informational, computational, and display needs of planning (Harris and Batty, 1993).

Relative to the rapid land use growth, various issues and problems arise especially those pertaining to environmental pollution, land use conflicts, as well as the availability of land for future development. The changes that occur necessitate continuous monitoring to ensure sustainable development in the environmental as well as socio-economic aspects. More important, assessment of these changes is crucial not only to understand and review current development scenarios, but also to predict changes that will occur, formulate policies and strategies, as well as control development. Toward better management of the metropolitan growth, faster planning decisions and careful management are imperative. Currently, more efforts are directed at assessing the ability to supply land and supporting infrastructure to meet future needs. What needed is a tool to better manage outward growth and channelling development into designated growth areas so as to strike a sustainable balance for economic growth and protection of environmental assets (Yaakup *et al.*, 2005b). Some of the important functions include the ability to retrieve information rapidly and efficiently, model different scenarios and evaluate alternative solutions generated by various modelling procedures. The GIS capabilities as a regional planning and management tool is further enhanced through integration with PSS and DSS.

INTEGRATED LAND USE ASSESSMENT (ILA) FRAMEWORK FOR KLANG VALLEY

The regional authority needs to approach physical, social, and economic development issues in an integrated and multifaceted manner. Working at the regional level to bridge the gap between regional policies and local circumstances would certainly need a common base of information and data which can help coordinate planning and development programmes at the local authorities level. At the same time, urban planning and management calls for a continuous evaluation and analysis of the current environment as well as the carrying capacity for future development. In the past, the number of alternative planning scenarios produced was rather limited mainly due to the time consuming procedures of creating scenarios as well as the evaluation that follows. Policy-makers, like most decision-makers, face the difficult task of evaluating and examining the impact of various resource allocations while the evaluation process appeared to be quite static and limited. Today, having prepared the evaluation model and facilitated by SPDSS, the operation can be accomplished within a much shorter time frame through computer processing of the data and computer mapping of the results.

In the case of Klang Valley, it took five years to establish the development of ILA model and verify the concept, and ILA is still under research and development (R&D) process. For the time being, ILA study undertaken is focusing more on model development and identifying the deriving factors involved; and conducting several case studies to establish the methodology using different software and methods. This paper outlines the concept of ILA and development of ILA model as well as illustrates two case studies undertaken towards establishing the model.

The Concept of ILA

The main purpose of introducing ILA is to create a relationship and subsequently integration between the sector-based applications previously developed in AGISwlk for generating the development scenario alternatives. The need for ILA is basically as follows:

- To act as a development planning mechanism at the regional level, with BKWPPLK using it as a guideline and reference for defining the suitable type of development in the future.
- To support land development control and provide a direction for development in Klang Valley through analysing the forecasted development scenarios.

ILA emphasizes on the concept of integration whereby relationship exists between the database developed in AGISwlk and implementation of application-based analyses in AGISwlk, with the use of planning support systems (Figure 1).

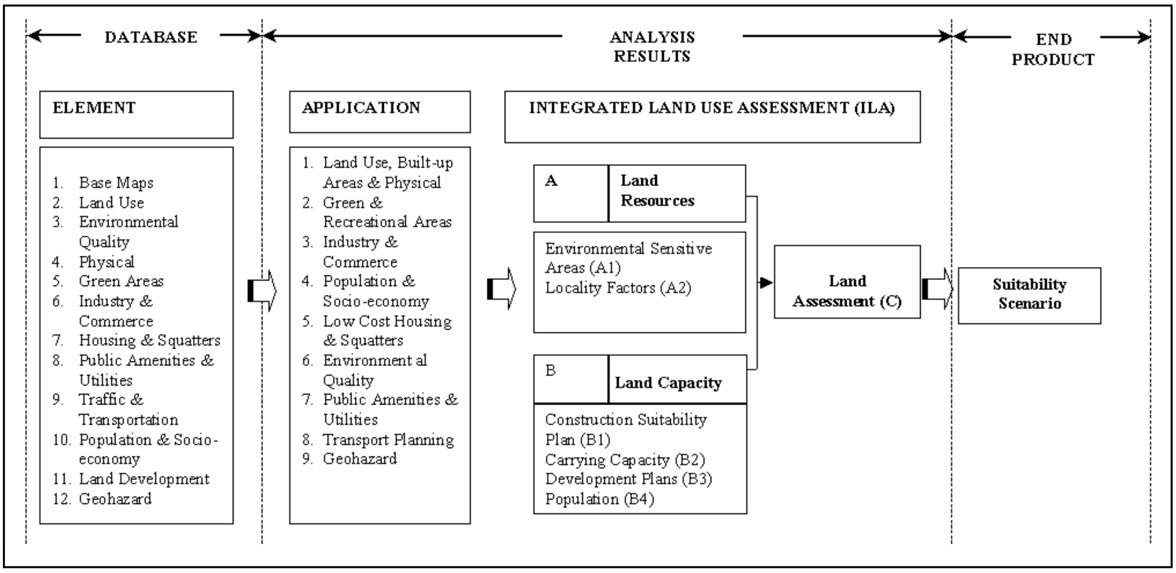


Figure 1 : The Concept of Integrated Land Use Assessment (ILA)

The ILA study approach to incorporate the physical and socioeconomic information to produce an integrated spatial and non-spatial analysis model that enables the generating of alternative development scenarios.

The Development of ILA model

The dynamic nature of planning and monitoring of development in Klang Valley region needs for a continuous evaluation and analysis of the current environment situation as well as its capacity for future development. In the planning evaluation process, it is important to have several alternatives, in which various factors such as the cost-benefit and the socio-economic characteristics have to be taken into account (Yaakup, 1991). Planners should be able to identify and make adjustments to deriving factors as well as evaluation criteria to develop scenarios for development alternatives to support the decision makers.

- ***ILA Model***

The ILA Model is dynamic in approach, providing flexibility for users in manipulating the selection criteria and organising them on priority basis depending on the development strategies considered. The assessment technique in ILA adopts the GIS spatial analysis technique combined with the weighting and sequential techniques. ILA involves two types of assessment namely Land Resources Assessment and Land Capacity Assessment (Figure 2).

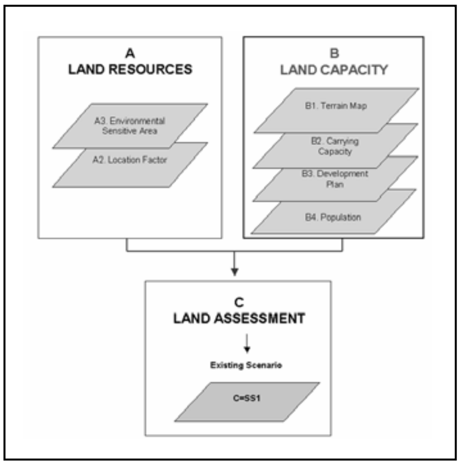


Figure 2 : ILA Model

Land Resources Assessment (A) aims at evaluating potential land resources for development in terms of supply by considering two deriving factors, which are Environmentally Sensitive Areas (ESAs) and Potential Areas for Development base on locality factors. Meanwhile, Land Capacity Assessment (B) evaluates the extent of acceptable development in terms of suitability and carrying capacity. The Land Capacity Assessment involves four deriving factors including Construction Suitability; Carrying Capacity for

River Basin, Transportation as well as Public Facilities; Development Plans; and Population (Yaakup *et al.*, 2005c).

- ***The deriving factors***

Apparently, a lot of criteria are involved in finding the suitable area for development. The deriving factors for ILA were identified through series of discussions with stakeholders throughout the study. Each deriving factor involves several selection criteria such as heritage value, hazard risk and life support in the case of ESA. The deriving and selection factors base on the ILA model were tabled while at the same time allowing users the choice and flexibility of redefining the factors to generate the scenario alternatives subject to the different policies, weight and rating concerned. Through continuous discussions and meetings with the Ministry of Federal Territories and stakeholders, the table of deriving factors was revised and updated (Appendix 1).

- ***Use of PSS and DSS software***

The ILA model is implemented through incorporation with the use of the *What if?* Planning Support System, which is a scenario base, policy-oriented planning support system that uses increasingly available GIS data to support community-based process of collaborative planning and collective decision-making (Klosterman, 2001). The use of *What if?* PSS Software in the study is to generate development scenario alternatives that can serve as basis for the formulation of more rational and effective development policies and strategies. While Decision Support Software DEFINITE is used to improve the quality of decision making through selection of better development alternatives.

IMPLEMENTATION OF ILA MODEL

Two case studies were conducted in applying the ILA model. The first case study aimed to identify and verify all the relevant factors necessary to generate of development scenarios alternatives using ‘what if’ approach. While the second case study was conducted with the attempt to evaluate the scenarios alternatives and select the best scenario using a decision support software (DSS).

Case study 1 : Sub river basins of Batu and Gombak

This was a preliminary study to design a model based on an integrated approach in generating development scenario alternatives while considering land resources and land capacity factors. ILA study was implemented for the sub river basins of Batu and Gombak, covering about 7,508.2 hectare of area in the District of Gombak in Klang Valley (Figure 3). In this study, the ILA model was applied to generate development scenario alternatives. Both types of assessment which are the Land Resources Assessment and Land Capacity Assessment were implemented but due to certain constraints not all the selection factors are used. The Land Resources Assessment was carried out by considering two deriving factors, which are Environmentally Sensitive Areas and Highly Potential Areas base on locality factors while Land Capacity Assessment only involved one deriving factor which is Construction Suitability (the terrain map).

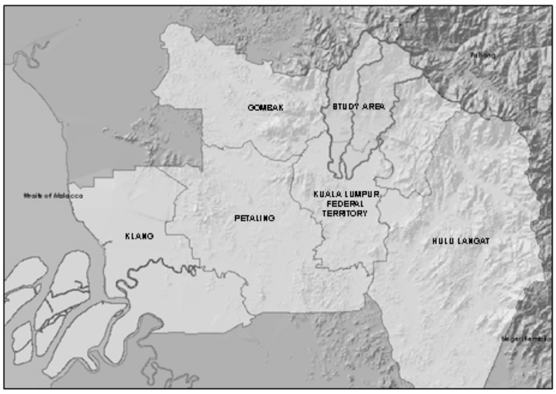


Figure 3 : Study area

- **Methodology**

There are altogether three main stages. The methodology was developed and organised based on the GIS spatial analysis process and *What if?* planning support system framework. The stages can be simplified as follows:

<u>Stage 1 : Identify Policy and Strategy</u>

This stage involves identification of policy and strategy to be used as guideline and direction of study in achieving the desired output.

<u>Stage 2 : Collecting Data for analysis</u>

The second stage involves identifying data in the AGISwlk database to be used for creating Uniform Analysis Zone (UAZ) based on predetermined selection factors. UAZs are GIS generated polygons, which are homogeneous in all respects considered in the model (Figure 4). For instance, all points within a UAZ have the same slope, are located in the same municipality, are within the same distance of an existing or proposed highway, and so on (Klosterman, 2001).

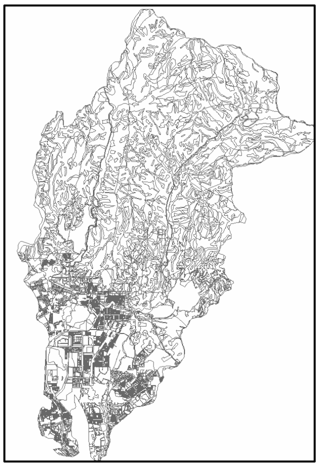


Figure 4 : Example of Uniform Analysis Zone (UAZ)

<u>Stage3 : Analysis and Modelling</u>

The analysis and modelling stage involves the process of creating *Uniform Analysis Zone* (UAZ), designing project file and conducting suitability analysis. The process of creating UAZ layer involved combining of GIS data layers. The GIS functions involved in the process are the overlay function, classification and measurement. Designing the project file is most important because it influence the suitability analysis and affects the resulting output. The suitability analysis involves three steps which are selecting the suitability factors, specifying factor weights and specifying factor ratings. In this study, a mathematical formula was applied for all factors considered in generating the development scenarios.

$$y = \sum_{i}^{n} w_i r_i$$

where

y : Score
w_i : Weight of suitability factor
r_i : Rating of factor category

- **Generated Scenarios For Land Assessment**

In this study, two scenario alternatives were generated (Figure 5) using different weight and rating appropriate to two different policies.

<u>Scenario 1</u>

In Scenario 1, the policy encourages development even in environmental sensitive areas and in potential areas base on locality factors. Scenario 1 shows 13.4% of land is suitable, 32.2% is moderately suitable, 40.9 % is less suitable while 13.5% is not suitable for development. This means 45.6% of land is suitable for development but certain environmental sensitive areas have to be sacrificed for development purpose. The scenario suggests more land available for development but the environmental impact will be inevitable such as the degradation of environmental quality.

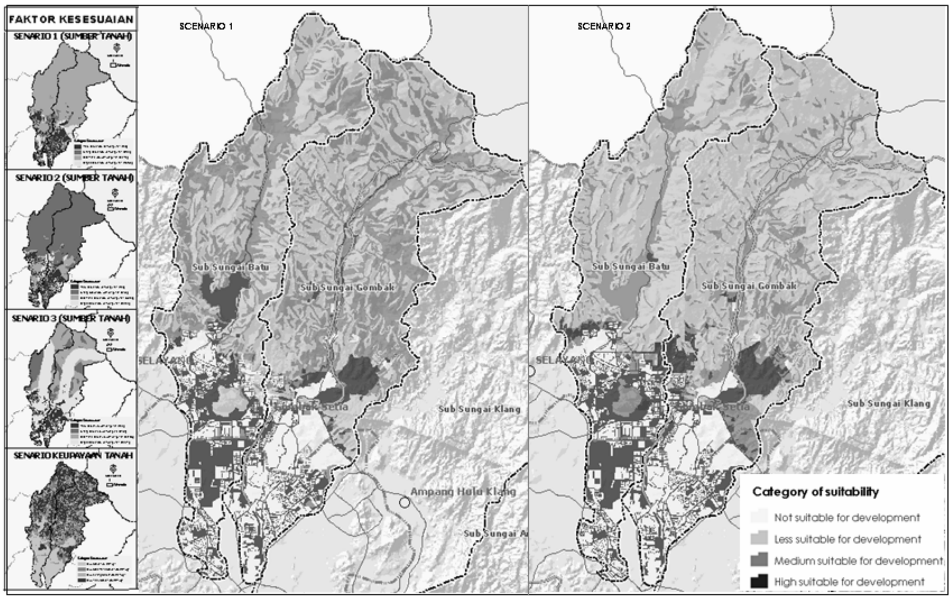


Figure 5 : Scenario 1 and 2 of Land Assessment

<u>Scenario 2</u>

In Scenario 2, the policy outlined that no development shall be carried out in Environmental Sensitive Areas. Scenario 2 shows 15.1% of land is suitable for development, 21.3% moderately suitable, 50.1% less suitable and 13.5% not suitable. This means 36.4% of land is suitable for development while at the same time the environmental sensitive areas are conserved.

Enhancement of ILA Methodology

The ILA methodology as used in the first study (Case Study 1) is further enhanced. Evaluation is an essential in the planning process especially in selecting the appropriate development scenario alternative to be implemented. As such, it is necessary for decision-makers to define the suitable planning evaluation model so that the development scenario chosen could cater for future planning and its implementation is beneficial to the public. In defining the planning evaluation model, the development scenario alternatives should satisfy various criteria such as taking into consideration the planning objectives proposed and measuring all the costs and benefits for every sector. The second study is the evaluation study to select the best scenario alternative to be implemented.

Case study 2 : District of Gombak

The area involved for this case study is Gombak. The District of Gombak covers an area of about 65,582.24 hectare (Figure 6). The main land use in the study area is the natural environment, covering more than half of the area (61.6%). In this study, the ILA sub model for Locality Factor was applied to generate scenario alternatives and evaluation process was carried out to select the best scenario.

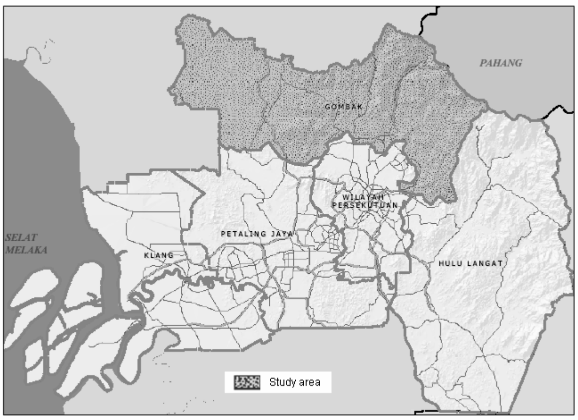


Figure 6 : Study area

- **Methodology**

The same methodology as in case study 1 was used with some enhancement in line with the purpose of study. Two main steps were involved. Step 1 is concerned with the development of alternative scenarios which consist of 3 stages as in the previous case study. The methodology for preparing UAZ layer is further simplified through the use of ArcGIS 9.x component called Modelbuilder for analysis and modelling the process of creating the UAZ which is incorporated into the ILA user interface developed. While Step 2 is regarding the assessment of alternative scenarios using the multi criteria technique for a better evaluation result. Step 2 involves 6 stages including to identify assessment criteria, set up the measurement scale for criteria assessment; multi criteria analysis and sensitivity analysis. Scenario assessment is done using the DEFINITE 2.0 software (Figure 7).

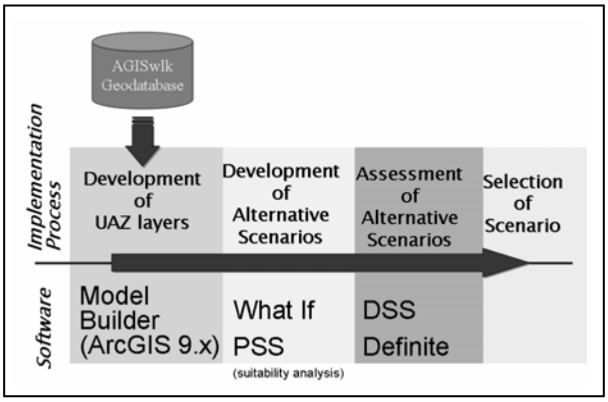


Figure 7 : Study Methodology

- **Generating Alternative Scenarios based on Locality factors**

The ILA user interface was designed to simplify the process of creating UAZ layer, which is required as input in generating scenarios using the *What if?* Planning Support System.

The main function of ILA PSS is to facilitate user in data organisation and preparation especially in preparing the UAZ layers based on the ILA model. Earlier, the UAZ layers are basically derived using the geoprocessing functions in ArcGIS. But through the geoprocessing functions provided in ILA PSS which was designed base on the sub models of each deriving factor in the ILA model, the process of creating the UAZ layer is made easier. Initially, the functions provided in ILA PSS were developed totally through VB programming, but the introduction of ModelBuilder as a geoprocessing analysis component in ArcGIS version 9 has very much simplified the process. The use of ModelBuilder has enabled several analyses to be executed simultaneously to obtain the end product faster. Figure 8 shows the process of creating UAZ layer required for generating development scenarios base on the locality factors. The UAZ layer created was then used as input to the *What if?*PSS.

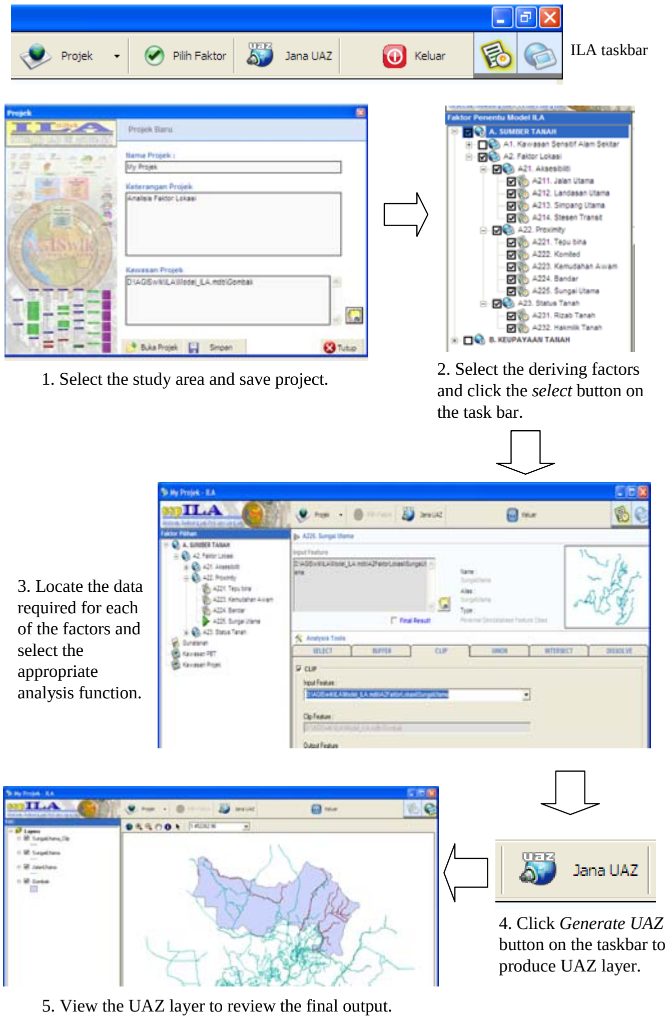


Figure 8 : The process of creating UAZ layer using ILA PSS

The user interface developed will allow user to change the parameter value in the model and subsequently generate the UAZ layer for the specific model. Basically, ILA PSS involves the use of the MS Visual Basic 6.0 software for its application and user interface development. MS Access is used for building the ILA PSS database which stores the parameter records and system variables. While the ArcGIS Engine Developer Kit is used as the programming component for the display and manipulation of the GIS data (Yaakup *et al.*, 2005c). ILA user interface can be used by the user with no prior experience of GIS software as well as the sophisticated user.

<u>Scenario 1 : Development concentrated outside the urban area</u>

Assumptions in Scenario 1 was based on the Land use and Physical Sector's general policy as stated in Inspection Report of Selangor State Structure Plan 2002-2020 (Laporan Pemeriksaan Rancangan Sruktur Negeri Selangor 2002-2020), which suggested development be focussed outside the urban areas. This is to address the issues of insufficient public facilities and infrastructures faced by the rural areas. The generated scenario indicated 46.56% of land as being moderately low, 37.09 % moderate and 0.10% moderately high in term of suitability for development (Figure 9).

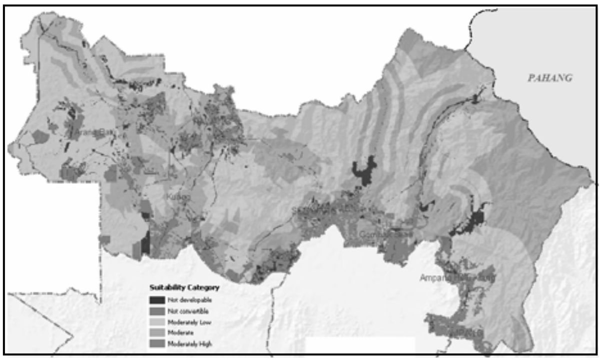


Figure 9 : Scenario 1

<u>Scenario 2 : Development encouraged near urban area, transit station and built-up area</u>

Assumption for scenario 2 was based on the strategy from the Klang Valley Perspective Plan (PELAWI I) which indicated the need to control land use growth along the main roads and need for high density development to be concentrated around the transit stations, urban areas and built up areas. The scenario generated attempted to visualize what if development is not encouraged near the main roads but focussed near the transit stations, urban areas and built up areas. Scenario 2 showed 0.61% of the area is moderately high in term of development suitability which include the area near Arang Batu, Rawang, Selayang, Gombak Setia, Ampang and Ampang Hulu Klang (Figure 10). Almost half the area (46.43%) fell under the category of moderately low in term of suitability for development.

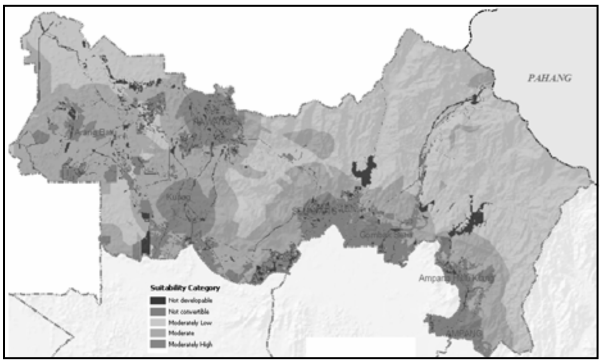
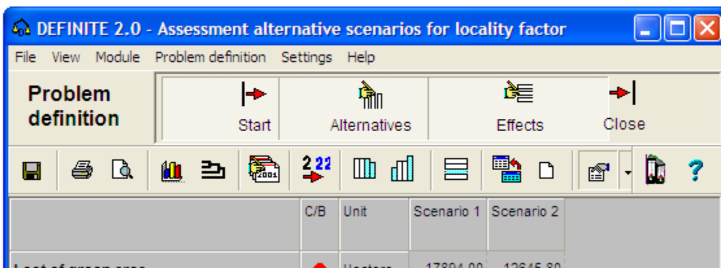


Figure 10 : Scenario 2

- **Scenario Assessment**

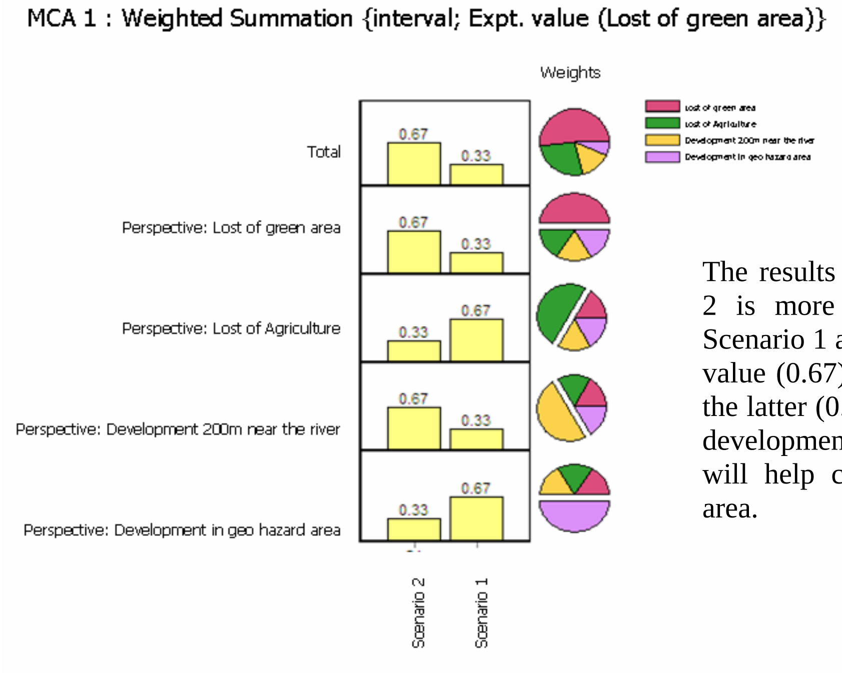
Apart from generating alternative development scenarios, evaluation becomes an essential step in the planning process especially in selecting the appropriate development alternative to be implemented. In this case study, selection is based on minimal environmental loss if development is to be imposed. Both scenarios were assessed in terms of spatial environmental impacts, particularly involving lost of green and agricultural land, as well as development within 200m from the rivers and in geohazard (flood) risk areas. The effects were assessed through quantitative measurement of area lost in unit of hectare based on the suitability for development (namely the moderately high and moderate category (Figure 11).



The multi criteria analysis were carried out using the weighted summation method and interval standardization for ranking of alternatives. Sensitivity analysis was also conducted to analyse the sensitivity of ranking through assessment of the score and weight uncertainty in defining the priority of the study's objectives concerned. Relative importance for each effects showed that loss of green area is most important compared to other effects. The results of the multi criteria analysis is as shown in Figure 12.

Method: Weighted summation   Analysis Description: MCA 4: Weighted summation {i

	C/B	Unit	Standardization method	Minimum Range	Maximum Range	Weight
Lost of green area		Hectare	interval	12645.80	17894.00	0.521
Lost of Agriculture		Hectare	interval	3993.60	7963.96	0.271
Development 200m near the river		Hectare	interval	2642.36	5394.76	0.146
Development in geo hazard area		Hectare	interval	1724.84	2141.64	0.063



The results indicates that Scenario 2 is more rational compared to Scenario 1 as its total accumulation value (0.67) is higher than that of the latter (0.33). Implementation of development based on Scenario 2 will help curb the loss of green area.

Figure 12 : Multicriteria analysis results

DISCUSSIONS

As it is understood that GIS was not originally designed or developed for the planning profession, planners have to adapt existing GIS tools to meet their needs. Traditional programming languages can be used to develop spatial analysis and modeling tools entirely independent of commercial packages. A combination of sophisticated GIS macro commands and traditional programming language also can be used to develop analytical models closely linked to full-featured GIS toolkits (Klosterman, 2001). A PSS therefore must combine traditional tools for urban and regional planning with other technologies such as expert system (Han and Kim, 1989), decision support aids such as multi-attribute utility theory (Lee and Hopkins, 1995), hyper media systems (Shiffer, 1992), and group decision support systems (Armstrong, 1993; Finaly and Marples, 1992).

From the ILA study carried out, several observations are derived:

i. The ILA user interface developed has help simplify and provide guidance in the process of creating UAZ layer, which is required in generating scenarios using the *What if?* Planning Support System. The ILA PSS provides a user-friendly interface to be used by user with little experience of GIS software as well as the sophisticated user.

ii. The model developed is dynamic in approach and provide flexibility in manipulating the selection criteria. The use of PSS and DSS software in implementing the study helps simplify the process of generating and assessing the alternative scenarios. It helps improve the quality of decision making.

iii. The involvements of stakeholders in sharing their expertise and experience had very much assisted in establishing the development of ILA model and identifying the deriving factors. The stakeholders which include government agencies and local authorities assisted and were involved in developing and designing the ILA model while at the same time co-operate with one another for sharing related information. Currently, the key stakeholders include The Department of Mineral and Geoscience (JMG), supporting in term of the terrain map development as required by one of ILA sub models and Department of Irrigation and Drainage (JPS) that supplied the river basin carrying capacity map.

The ever-accelerating growth of computer technology especially that involving SPDSS have further simplified the method of land and environmental assessment. The implementation of ILA supported by the *What if?* PSS and DFINITE DSS resulted in a more integrated planning and serves as a good alternative in producing more rational decisions. ILA has all the components as a planning support system. ILA incorporates data and data manipulation procedures, user interface and a system which links and coordinates models and data. ILA has the edge over conventional geographical information systems in that it incorporates a greater level of analytic and statistical modeling than is required to assist the process of decision making. The use of ILA for controlling, monitoring and managing development is hoped to facilitate planning and management agencies in deriving at more effective decisions towards sustainable metropolitan development.

The implementation of ILA is seen as a comprehensive approach to assess and control urban growth. The framework helps the regional authority identify trends within the region, recognize the needs of its residents, and assists in developing programs and policies that address these needs. The data sharing framework in ILA provides a more efficient, more effective, and less expensive method of sharing and coordinating information between stakeholders. This framework is built upon enhancement from individual project's assessment towards integrated regional systems. It takes into consideration the technological capability to share information across political borders and between departments and agencies so as to promote partnership and collaboration in the face of common problems and challenges. All in all, the implementation of ILA will enable stakeholders to employ

GIS much more quickly and cheaply than if they were to implement GIS individually (Yaakup *et al.*, 2005b).

At the moment, work is still underway in establishing collaboration with all possible government stakeholders. It is envisaged that through the development, application and evaluation of the case study of regional spatial scale, the ILA framework can be possibly extended to all local authorities and stakeholder agencies so as to move toward better governance.

CONCLUSION

With its powerful capacity for spatial data management, spatial analysis, and visualization by using GIS as its core, the system provides planners with new tools to implement their work more efficiently especially with support of the interactive and user-friendly interface developed to ease the use of the sophisticated system without the need for advanced technical skills. In addition, the web-based GIS application introduced is expected to induce meaningful public participation, apart from better data integration and sharing through effective data dissemination techniques toward collaborative planning.

However, it is clear that the SPDSS operates to simplify the real decisional process. In fact, it doesn't want to take the place of the decision maker, but just to give him a valid aid. Professional input and stakeholders' collaboration are still the key factor to obtaining rational set of alternatives and thus leads to the selection of the best scenario in the quest to realise sustainable development.

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Appendix 1: Selection Factors For ILA Model (Version 2.8)

FACTOR	DERIVING FACTOR	SELECTION FACTOR	SPECIFIC SELECTION FACTOR			OUTPUT
A. Land Resources	A1. Environmental Sensitive Area	A11. Heritage	A111. Historical, monument and archaeology	Buildings		1. Very Critical 2. Critical 3. High Sensitivity 4. Medium Sensitivity 5. Low sensitivity
				Hills		
				Caves		
				Villages		
				Archaeology Sites		
			A112. Biodiversity	Reserved Forest		
				Wild Life reserves		
			A113. Geology	Unique Rock	Limestone Hill	
					Sedimentary rock	
				Ex-mining area	Major Coal Mine (Batu Arang)	
					Biggest & deepest mine (Sungai Besi)	
					Major Tin mine (Perigi Tujuh Serendah)	
				Hot Spring Area		
			A114. Landscape	Public recreation Park		
		A12. Geohazard Risk	A121. Landslide	Hill Area		1. Very Critical 2. Critical 3. High Sensitivity 4. Medium Sensitivity 5. Low sensitivity
			A122. Flood	Natural retention area		
			A123. Land Subsidence	Limestone, ex-mining land		
			A124. Erosion	Beach		
				River		
				Pond		
				Island		
		A13. Life Support	A131. Fresh Water Supply	Groundwater		1. Very Critical 2. Critical 3. High Sensitivity 4. Medium Sensitivity 5. Low sensitivity
				Dam		
				Drainage System - River		
			A132. Food	Aquaculture area - Resources		
				Crops area - Resources		

				Poultry area - Resources		
				Agriculture Industry Center		
				Research Station - institution		
			A133. Energy and Building Materials Resources	Mineral Metallic	Tin	
				Industrial mineral resources area	Sand	
					Aggregate rock	
					Clay	
	A2. Locality Factors	A21. Accessibility	A211. Main road			1. High 2. Medium 3. Low
			A222. Main Railways			
			A223. Main Junction			
			A224. Transit Station			
		A22. Proximity	A221. Built up area			1. High 2. Medium 3. Low
			A222. Committed Development			
			A223. Public Amenities			
			A224. Town Centre			
			A225. Main River			
		A23. Land Status	A231. Land Reserve			
			A232. Land Ownership			
B. Land Capacity	B1. Construction Suitability (Terrain Map)	B11. Slope				1. Class I 2. Class II 3. Class III 4. Class IV
		B12. Elevation				
		B13. Activity				
		B14. Erosion & Stability				
	B2. Carrying Capacity	B21. Transportation	B211. Road	Main road		Level of Services (LoS) 1. Class A 2. Class B 3. Class C 4. Class D 5. Class E 6. Class F